# Cold Weather Injury Risk Analysis and Management in a Tasmanian Army Reserve Battalion

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## Abstract

Cold Weather Injury (CWI) is a significant threat to military capability in Tasmania. In 2011, the Royal Tasmanian Regiment implemented a cold weather training policy and training package to formalise risk management and preserve military capability in training and operations. This article summarises relevant literature pertaining to military CWI and outlines an approach to risk mitigation based on the hierarchy of controls. A whole of command approach to preserving capability and preventing casualties in cold climate training is outlined and potential broader applications of this approach are discussed.

## Introduction

Since the death of a soldier in training in 2004[1], the Australian Defence Force (ADF) has instituted a comprehensive heat injury management project to prevent further casualties. Cold Weather Injury (CWI) has been a less conspicuous feature of Australian military risk management, despite its significant historical threat to military capability. The recently introduced Work Health and Safety Act 2011 and associated regulations however specifically require Defence to ensure that members 'carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety'[2], making consideration of CWI risk management timely. This article outlines risk factors for CWI identified in both military and civilian medical literature and describes a recently adopted cold injury prevention policy adopted by the 12th/40th Battalion, the Royal Tasmanian Regiment (12/40 RTR), an Army Reserve formation based in Hobart and Launceston.

## Terminology

There are three principle categories of CWI: hypothermia, frostbite and non-freezing cold injury (NFCI)[3]. Hypothermia is a systemic injury diagnosed when core body temperature falls to 35.0°C or below. Frostbite is a peripheral injury characterised by crystallisation of fluids in the skin and subcutaneous tissues at temperatures less than -0.55°C (the freezing point of skin), followed by reperfusion injury that occurs with rewarming. NFCI is also a peripheral injury, which generally occurs between temperatures of 0.0 – 15.0°C and encompasses the previously recognised presentations of trench foot, immersion foot and chilblains.[4] Four phases of NFCI have been described: (1) during cold exposure, characterised by vasoconstriction and local cold neuropathy; (2) during rewarming after cold exposure, characterised by mottling and emergent swelling; (3) hyperaemia, characterised by paraesthesia and pain; and (4) following hyperaemia, characterised by resolution or permanent neurological sequelae.[3, 5, 6]

## Epidemiology

Analysis of the epidemiology of CWI is subject to two limitations: firstly, the data are highly influenced by geographic and ethnic variation; secondly, available data are most frequently drawn from self-reporting and self-presentation to first aid posts and are therefore likely to significantly underestimate the true incidence of CWI. Oakley[7] describes winter training exercises in which up to 50% of soldiers have features of NFCI but where only a handful seek medical attention. Under-recognition has been compounded in the past by the absence of an ICD-9 code for NFCI, which led to development of cold-injury specific survey instruments by the UK Ministry of Defence[7]. Subsequent increases in CWI incidence may reflect increased detection rather than increased occurrence.

## Risk Factors

Conceptually, the risk of cold injury may be understood as a balance between the 'cold dose', which is a product of the duration and severity of cold exposure, and 'cold resilience', which is determined by each individual's degree of cold adaptability, or 'thermocompetence', and by access to technology and clothing.

**Cold Dose**

The most recognised risk factors for CWI are immersion, rain and wind. Water is more than seventy times more effective in transferring heat compared with air; therefore, considerable heat may be lost during exercise in relatively mild temperatures if the subject is wet.[8] Indeed, the largest U.S. study of CWI recorded casualties in the comparatively warm climates of Hawaii and Florida.[8] The apparent temperature, or 'wind chill', index is commonly used to estimate the cooling power of an environment. It estimates the equivalent still-air temperature at which heat loss through bare skin would equal heat lost in the recorded windy conditions. It does not consider man-made air movement, such as that created by running or vehicular travel[9]. The wind chill index is predominately associated with the risk of freezing cold injury rather than hypothermia; however, in the absence of a workable alternative, it has been adopted by several military forces as an overall indicator of cold stress.[10]

**Cold Resilience**

The first category of factors affecting cold resilience relate to heat loss. Anthropometric characteristics influence CWI risk and, in general, subjects with a higher body fat percentage maintain core body temperature better than leaner subjects. Relatively underperfused muscle at rest can also provide insulation, though this effect is diminished markedly by exercise.[8]

The second category of factors affecting cold resilience relate to decreased heat production. Hypoglycaemia impairs core temperature maintenance because it inhibits shivering through central nervous system effects. Food restriction for forty-eight hours has been shown to impair shivering, even in the absence of hypothermia.[8] Fatigue and lack of sleep exert similar effects.

In addition to the risk factors described above, which apply equally to civilian populations, the incidence of cold injury among British and United States military forces has been found to be inversely proportional to length of service, rank, level of education and ethnicity.[10, 11] Soldiers of African-American or Afro-Caribbean descent, independent of their place of birth, are over thirteen times more likely to experience CWI even after controlling for rank and education. Of greater relevance for Australian forces, Pacific Islanders training in the U.K. were 2.5 times more likely to suffer CWI than Anglo-Saxon comparisons[11] and soldiers from warmer latitudes are more likely to experience CWI on exercise or operations in colder climates.[8] These data demonstrate that soldier demographic characteristics may be used to identify those individuals at particular risk of CWI, thereby shaping control measures.

Interestingly in the 1990s, both the United States Army and the Israeli Defence Forces recorded that the majority of cold injuries (hypothermia and NFCI) occurred during routine training exercises rather than combat operations.[10, 12, 13] One explanation for this is differences in individuals' behaviour and commanders' risk-management in training and operational environments.

## Cold Weather Training in Tasmania

Cold weather has always represented a significant threat to military capability in Tasmania. Both sub-zero temperatures and snow have been recorded at Buckland Military Training Area and Pontville Small Arms Range in recent years[14]; these facilities are frequently used by 12/40 RTR. However, two events in 2011 heightened awareness of CWI risk management by 12/40 RTR. Firstly, in May 2011, during final planning for an infantry minor tactics exercise it was identified that some soldiers had not been issued winter weight sleeping bags upon completion of recruit training, as a temporary modification of the block scale had apparently removed the entitlement from Army Reserve soldiers. Secondly, officer professional development training in Strathgordon was cancelled at late notice due to sleet, snow and black ice.

These events suggested that risk mitigation of CWI within the battalion was being hampered by lack of published decision aids for commanders at all levels. Moreover, the equipment deficiency described above was not identified until after the commencement of the yearly training cycle, thereby exposing soldiers to the risk of cold injury; therefore, it was thought necessary to formalise the battalion's approach to cold injury prevention. It was felt that, even though no casualties had been sustained from CWI, there was likely to be an unrecognised diminution of soldiers' endurance, fine motor skills and cognitive performance, as recognised in overseas military models.[15, 16]

## Military Risk Management Approaches

The Defence Work Health and Safety Strategy 2012-2017[17] requires that all units seek 'upstream safety' and maintain a safety culture. In order to achieve these objectives in the field of CWI, the battalion applied the WHS paradigm of risk identification and assessment, followed by risk control and on-going monitoring[18].

**Risk Identification and Assessment**

The methods proposed to ensure identification of high risk periods for CWI are analysis of historical climate data, review of long-range meteorological forecasts and periodic apparent temperature monitoring during operations by a designated Cold Injury Control Officer (CICO). The CICO would refer to the Bureau of Meteorology thermal comfort observations for the weather station closest to the operational area; these data are updated hourly and include both temperature and wind speed. At present, no anemometer is available for local wind speed monitoring in more remote locations, though this would enhance risk identification.

**Control Measures**

Control measures were then developed with reference to the hierarchy of control. The controls, in approximate order of their effectiveness in risk management, are: elimination of the hazard, substitution or modification of the hazard, isolation of the hazard, engineering controls, administrative controls and personal protective equipment (PPE).[19,20]

Recognising that cold and wet climatic conditions are a perennial feature of Tasmanian operational environments, the cold weather training policy that was developed recommends substitution of theoretical or barracks-based training during periods of high cold injury risk, and provides materials such as weather charts and apparent temperature formulae to facilitate staff in scheduling their training during the safest part of the year. Engineering controls are also mandated by the policy, including the availability of a re-warming facility or tent.

The remainder of the cold weather policy addresses administrative controls, for example water immersion guidelines, food and water intake guidelines, and apparent temperature monitoring. The CICO uses hourly apparent temperature data to derive a 'work-warming routine' from a matrix published in the cold weather policy document. The policy also specifies the type of personal protective equipment that must be available to all soldiers prior to the commencement of training when there is a risk of cold weather injury. Finally, education is recognised as an important administrative control and an annual force preservation training package has been developed, which includes a 'soldiers five' to aid early recognition of symptoms and provision of appropriate first aid.

Importantly, the cold weather policy emphasises that leaders at all levels of the chain of command are individually responsible for CWI risk identification and mitigation. Specific responsibilities are outlined for platoon commanders, company headquarters, battalion headquarters, Administration Company and the regimental nursing officer. As mentioned above, the policy requires appointment of a CICO within platoons or sections for all field training. The CICO is responsible for maintaining environmental situational awareness and for supervising the regular inspections of soldiers' feet, hands, face and clothing to ensure compliance with the risk management guidelines.

**Monitoring and Review Mechanisms**

Recognising that members who have previously experienced an episode of hypothermia or NFCI are at higher risk of becoming cold casualties in future training, the 12/40 RTR cold weather policy dictates that a cold casualty register be established and maintained. This will allow both the on-going epidemiological monitoring of high-risk soldiers on each field training exercise and monitoring of the cold weather policy's effectiveness. All CWI identified in training are to be subjected to Quick Assessment and those resulting in hospitalisation will be addressed by a Routine Inquiry in order to evaluate the effectiveness of extant control measures. The findings of these investigations are to be documented in routine Post Activity Reports (PAR) alongside other training outcomes. Additionally, the policy mandates that CWI is specifically considered in all pre-activity risk assessments, with reference to previous PARs and any shortcomings of prior control measures. In this way, the cold weather policy is consistent with the regulatory requirements outlined in Work Health and Safety Regulations 2011.[18]

## Evaluation of Program Effectiveness

While the cold weather training policy has only recently been adopted by the battalion, the drafting process has allowed the chain of command to realise the need for an integrated approach to cold injury prevention, leading to subsequent development of a mandatory yearly education package, to be delivered at Force Preservation Training, and a 'soldiers five' for all new personnel marching into the battalion. Additionally, the cold weather policy provided guidance on the procurement of cold weather sleeping bags for soldiers and offers guidance on the scheduling of training to mitigate the risks imposed by insufficient cold weather equipment. Already, the officer and senior non-commissioned officer training for 2012 has been rescheduled to mitigate the risk of cold injury, and mandatory checks of all new soldiers' cold weather equipment have been instituted, ensuring that the two sentinel events that prompted development of the cold weather policy are less likely to occur in future.

From 2012, as a result of the cold weather policy, the decision to continue, suspend, cancel or reschedule training due to adverse climatic conditions will be based on unambiguous, evidence-based guidance. Moreover, commanders will be required to specifically approve the continuation of training in circumstances where the policy would otherwise suggest its discontinuation, thereby enhancing accountability. This demonstrates that the mere introduction of a cold weather policy can improve the safety culture of a formation by mandating consideration, at regular intervals, of a serious threat to military capability.

This policy and associated learning package have the potential to dramatically reduce the impact of cold casualties on military training in Tasmania. Cold injury, like heat injury, is almost always preventable and therefore any casualties that occur have a significant detrimental effect on morale and public perception of the military. By specifically assigning responsibility for different levels of risk mitigation and by integrating the policy with regular education of all ranks, the policy ensures that even when cold injuries do occur, they are recognised early and appropriately scrutinised to avoid recurrence.

To our knowledge, there are few or no comparable Australian Army policies for prevention, recognition, management and reporting of cold injuries. Moreover, the 12/40 RTR cold injury policy is part of an integrated cold weather training package that will be implemented for all new and existing members of the battalion. Several aspects of the policy have been influenced by 'best practice' as recognised by other military forces, including the US Army; however, the 12/40 RTR policy differs from these existing guidelines in providing specific guidance to all levels of command on their responsibilities within the overall risk control hierarchy. Moreover, the establishment of a cold injury register for casualty tracking and epidemiological monitoring has not been identified in any extant policy.

## Broader Applications of Cold Weather Policies and Training

Due to the diversity of Army's current operational environments, this policy or similar documents are of broader relevance. Cold injury management is of particular significance in training environments, where environmental conditions are one of the most direct threats to the lives of soldiers. Any death or serious injury in training represents not only a grievous loss for the casualty's fellow soldiers but also creates potential for highly negative media exposure for the Army and Australian Defence Force more broadly. This principle can be seen in the previous media reporting of Australian heat casualties that have occurred on exercise rather than during operations overseas. Subsequent implementation of a comprehensive Army heat injury management package has not only minimised the risk of further casualties, but has also forestalled any claim made in hindsight that important safety issues were not considered during the planning and conduct of training.

Like heat injury, cold injury can occur in almost any training location throughout Australia, even places that are generally considered 'warm'. Consequently, as for heat injuries, cold injury prevention may not be considered unless prompted. Therefore, implementation of a cold weather policy, or policies, by individual units or formations potentially has the same importance as the Army's heat policy. Moreover, the skills required to optimise soldiers' performance in cold climates are transferrable to a wide variety of operational environments.

## Conclusion

CWI is a potentially significant threat to military capability throughout Australia. Without active case-finding, CWI may be overlooked in current risk management practice because the incidence of death or reported injury is low. However, a CWI is a sentinel event, representing a failure of WHS processes within an organisation and indicating the requirement for procedural review. Moreover, international research demonstrates that there is likely to be significant unrecognised degradation of capability preceding documented injury. Therefore, risk management should be systematic, not only to prevent casualties, but to ensure that all soldiers operate at peak performance at all times, in all environments.

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